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Submission to Prairie Provinces Water Board For Reconsideration of Alberta 1
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SUBMISSION
TO
PRAIRIE PROVINCES WATER BOARD
FOR
RECONSIDERATION OF ALBERTA'S ALLOCATIONS
FOR ITS
IRRIGATION PROJECTS

A. G. Underhill
Water Resources
Government of Alberta

January, 1964

Edmonton, Alberta, Canada

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SUBMISSION TO PRAIRIE PROVINCES WATER BOARD FOR RECONSIDERATION OF ALBERTA'S ALLOCATIONS FOR ITS IRRIGATION PROJECTS

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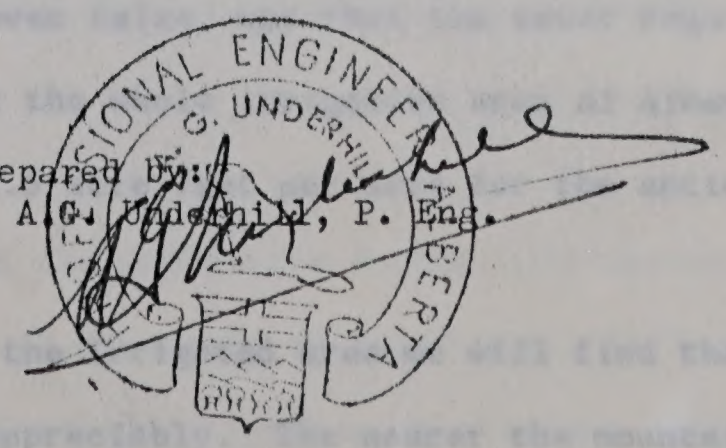
Submitted by:
Honourable H.E. Strom, Minister
Department of Agriculture
Province of Alberta.

January 1964.



Prepared By:
A.G. Underhill, P. Eng.

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Submission to The Prairie Provinces Water Board for Reconsideration of Alberta's Allocations for its Irrigation Projects

In 1949 the Province of Alberta requested an allocation of water for various irrigation projects from The Prairie Provinces Water Board. The Board reviewed Alberta's request and in 1951 they allocated water for the following:

PROJECT	IRRIGABLE AREA IN ACRES	ALLOCATION IN ACRE FEET
Eastern Irrigation District	281,000	562,000
Western Irrigation District	50,000	85,700
Bow River Project	240,000	478,534
Lethbridge Northern Irrigation District	96,135	150,000
St. Mary-Milk Rivers Project	465,000	796,000
United Irrigation District	34,000	51,000
Aetna Irrigation District	7,300	13,000
Mountain View Irrigation District	3,600	6,000
Leavitt Irrigation District	4,400	7,000
Macleod Irrigation District	5,000	8,000
Private Projects	70,000	80,000
	1,256,435	2,237,234

This request was prepared with the best knowledge that was available at that time (1949) regarding the requirements for irrigation projects. During the intervening time our irrigation projects have expanded, irrigation has become more intensified and our knowledge of the water requirements has increased.

The dry years of 1960 and 1961 have made it abundantly clear that our present allocations are not sufficient. Not only are they inadequate to meet anticipated demands but, in fact, they are not even sufficient to satisfy some of the projects at their present stage of development.

Investigations have shown that the earlier methods used in the calculation of Alberta's irrigation requirements assumed that irrigation on larger fields could be done as efficiently as that on smaller experimental plots. This assumption is now known to be incorrect. Under the controlled conditions in a farm experimental station, farm efficiencies of about 95% to 100% can be obtained whereas the average farm efficiency on an operating irrigation district is less than 50%.

A second assumption, which has been proven false, was that the water required for irrigating a crop was constant throughout the whole irrigation area of Alberta. This produced a constant "duty of water" of 1.5 acre feet per acre for the entire area.

If we note the meteorological data for the irrigated area we will find that both the temperature and precipitation vary appreciably. The nearer the mountains the higher the precipitation and the less need there is for irrigation. Similarly

Supplement to the Prairie Provinces Water Board
for Reconsideration of Alberta's Allocations for Irrigation Projects

In 1949 the Province of Alberta requested an allocation of water for various irrigation projects from the Prairie Provinces Water Board. The Board reviewed Alberta's request and in 1951 they allocated water for the following:

PROJECT	ALLOCATION IN ACRE FEET	IRRIGABLE AREA IN ACRES
Eastern Irrigation District	205,000	285,000
Western Irrigation District	82,700	80,000
Bow River Project	418,500	340,000
Lethbridge Northern Irrigation District	120,000	96,132
St. Mary-Milk Rivers Project	396,000	283,000
United Irrigation District	51,000	36,000
Vauxhall Irrigation District	13,000	7,300
Bonnykalm View Irrigation District	6,000	3,800
Travers Irrigation District	7,000	4,400
Medicine Hat Irrigation District	8,000	5,000
Taber Irrigation District	80,000	50,000

This request was prepared with the best knowledge that was available at that time (1949) regarding the requirements for irrigation projects. During the interval water requirements had increased and our knowledge of the water requirements has increased. Irrigation has become more important and more projects have expanded. Irrigation has become more important and more projects have expanded. Irrigation projects from The Prairie Provinces Water Board. The Board reviewed Alberta's request and in 1951 they allocated water for the following:

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Supplement to the Prairie Provinces Water Board
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the further east you go in southern Alberta the higher in general is the average temperature. The higher the average temperature the greater will be the amount of water required to grow a given crop.

Another important factor is the longer growing season in the eastern areas. If a reasonable water requirement for the Alberta districts is to be determined, there must be a variable "duty of water" which will accommodate the consumptive use requirements and the effective precipitation.

The irrigation factor of 80%, which was formerly used in the calculation of the area irrigated in any one season, has been found to vary also with different districts and different conditions. A change in the attitude of the irrigation farmer which has resulted in a more intensive use of his irrigated land has resulted in much higher irrigation efficiencies on some projects. This is especially true in the areas which have changed predominantly to the growing of alfalfa and grass. A very serious interest in land improvement by levelling and improved irrigation practices has also been noted in the last few years.

It has been found necessary to make some alterations in the estimate of conveyance losses and return flows. These have been changed to conform with present improved knowledge resulting from the data collected over the last ten years.

This request for a review and increase in water allocations for Alberta is based therefore on actual needs for greater amounts of water for use by irrigation projects.

The "Underhill Report" on Irrigation Water Use (1963) has dealt rather thoroughly with the problem, both here in Alberta and elsewhere. This report, in principal, is used as a basis for Alberta's request for new allocations. However, the report deals with the long range requirements and, since Alberta's allocations are subject to a continuing review, we feel that we should base our request on a somewhat shorter period.

This submission is therefore based on calculation in which the following arguments have been used.

Irrigation Factor

While in the long range view we believe the irrigation factor will approach 100%, it will probably be less than this in all districts at least until 1970. Some districts, notably those with the more concentrated irrigation development, will approach the 100% much faster than those where a less concentrated crop production

pattern occurs. These latter districts are generally in the areas where the precipitation is greater and the growing season shorter, and where the cattle economy is most prominent.

Irrigation Efficiency

It is agreed that by 1980 a 60% irrigation efficiency could be reached but in our submission, which is based on a shorter term period, this figure has been reduced to that estimated to generally prevail in the year 1970. In certain districts there will be considerable improvement over the next ten years, particularly with respect to land improvement by levelling. Irrigation extension work by the Agriculture Department will also improve irrigation practices. In the fringe areas, however, the increase in irrigation efficiency will be much slower and this is given consideration in the irrigation efficiencies used for the individual projects.

Conveyance Losses

Conveyance losses have been altered as a result of increased knowledge in this regard.

Return Flows

Return flows, which were not included in the original submission, have been included in this request. These are based on the results of stream flow measurements and other information which is available.

Net Depletion

The net depletion, which is an estimate of the actual amount by which an irrigation project will reduce the flow in the stream, is determined by calculation. The sum of these figures for all the projects represents the total amount of water which Alberta will actually be removing from the source of supply under maximum acreage irrigation.

This submission requests that the allocations of water for irrigation on the projects in the Province of Alberta, listed below, be set as follows:

PROJECT	IRRIGABLE AREA IN ACRES	GROSS DIVERSION IN AC. FT.	NET DEPLETION IN AC. FT.
Eastern Irrigation District	281,000	840,893	504,536
Western Irrigation District	75,000	143,142	78,728
		7,150*	1,800*
Bow River Project	240,000	718,200	466,830
Lethbridge Northern Irrigation District	~~9,600~~ 96,000	185,349	120,477
St.Mary-Milk Rivers Development	465,000	1,209,715	786,315
United Irrigation District	34,000	61,394	36,836
Aetna Irrigation District	7,300	14,683	8,810
Mountain View Irrigation District	3,600	7,241	4,345
Leavitt Irrigation District	4,400	8,850	5,310
Macleod Irrigation District	5,000	9,543	6,203
Ross Creek Irrigation District	2,300	6,417	4,492
Small Projects	70,000	87,500	61,250
	1,283,600 Ac.	3,300,077 Ac.Ft.	2,085,932 Ac.Ft.

* Special Stockwater Allowance.

PROJECT	IRRIGABLE AREA IN ACRES	CROSS DIVERSION IN AC. FT.	NET DEPLETION IN AC. FT.
Eastern Irrigation District	181,000	840,883	504,530
Western Irrigation District	25,000	143,143	85,886
Yuma Mesa Irrigation District	40,000	172,500	103,500
Colorado River Project	240,000	1,720*	1,032*
Coachella Valley County Water District	69,000	282,345	172,407
Imperial Irrigation District	463,000	1,509,212	905,527
Palo Verde Irrigation District	104,500	431,625	258,975
Gila Project	17,000	68,000	40,800
Wellton-Mohawk Irrigation & Drainage District	75,000	300,000	180,000
Unit B Irrigation District	28,000	112,000	67,200
Unit A Irrigation District	11,000	44,000	26,400
Yuma Project Reservation Division	13,000	52,000	31,200
Yuma Project Indian Reservation Division	3,000	12,000	7,200
Yuma Project Indian Reservation Division	1,000	4,000	2,400
Yuma Project Indian Reservation Division	2,000	8,000	4,800
Yuma Project Indian Reservation Division	3,000	12,000	7,200
Yuma Project Indian Reservation Division	5,000	20,000	12,000
Yuma Project Indian Reservation Division	10,000	40,000	24,000
Yuma Project Indian Reservation Division	1,000	4,000	2,400

$$\frac{\text{Gross Diversion}}{\text{Irrigable Area}} = 2.57 \text{ ac.ft./ac.}$$

$$\frac{\text{Net Depletion}}{\text{Irrigable Area}} = 1.63 \text{ ac.ft./ac.}$$

In addition to this water for irrigation purposes, each of these projects have municipal, industrial and other types of projects which they supply with water. This water is supplied to the individual users through the works of the individual irrigation projects.

The following lists those projects for which additional gross diversions are required for each project:

PROJECT	GROSS DIVERSION IN ACRE FEET	NET DEPLETION IN ACRE FEET
Eastern Irrigation District	38,660	19,330
Western Irrigation District	9,133	4,566
Bow River Project	2,480	1,240
Lethbridge Northern Irrigation District	2,300	1,150
St. Mary-Milk Rivers Development	14,615	7,307
United Irrigation District	-	-
Aetna Irrigation District	-	-
Mountain View Irrigation District	-	-
Leavitt Irrigation District	-	-
Macleod Irrigation District	-	-
Ross Creek Irrigation District	-	-
Small Project	-	-
	67,188 ac.ft.	33,593 ac.ft.

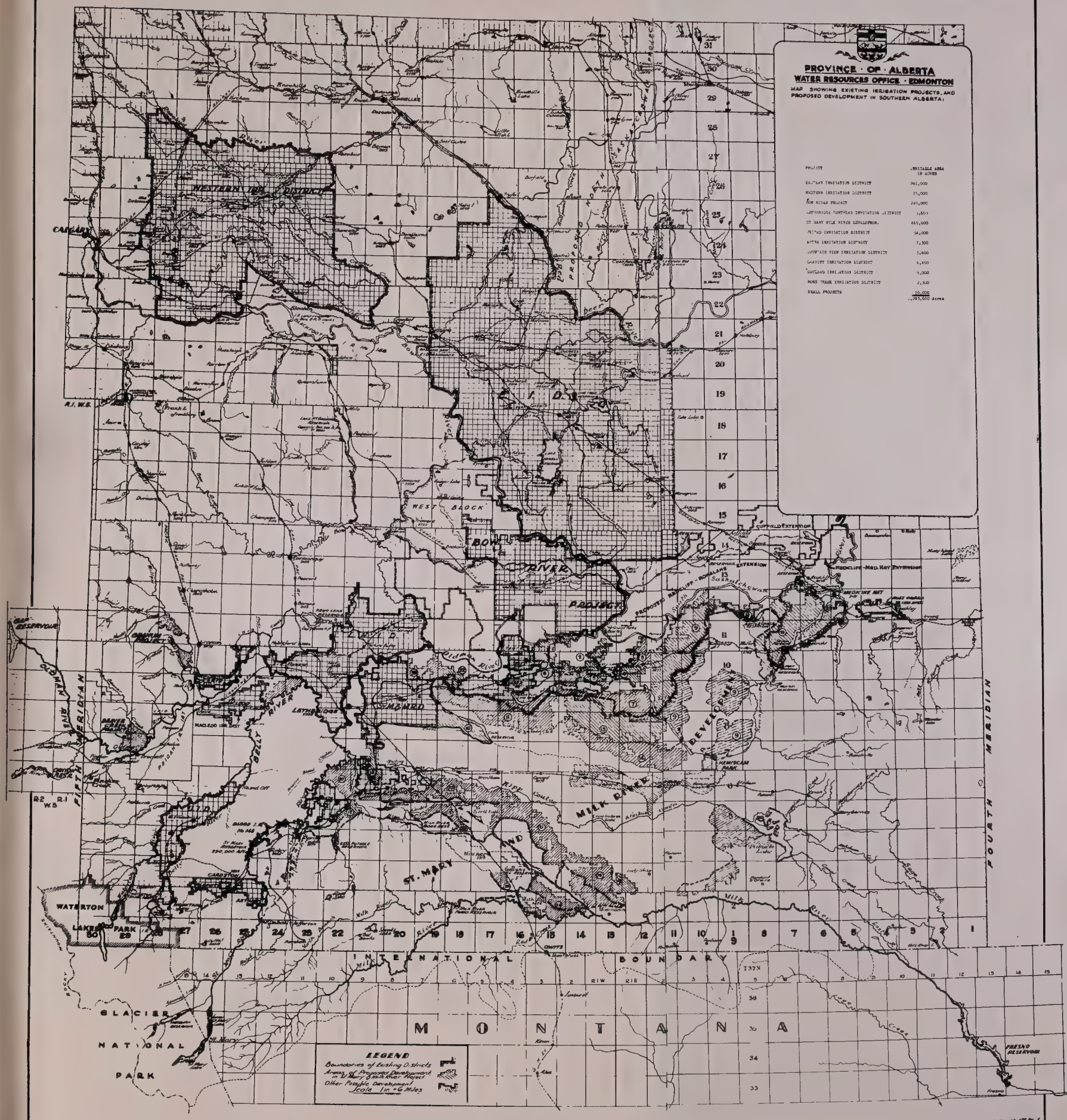
Thus, if these allocations are to be made for all purposes for which diversions are made, the allocations should be as follows:

PROJECT	IRRIGABLE AREA	GROSS DIVERSION	NET DEPLETION
Eastern Irrigation District	281,000	879,553	523,866
Western Irrigation District	75,000	159,425	85,094
Bow River Project	240,000	720,680	468,070
Lethbridge Northern Irrigation District	9,600	187,649	121,627
St. Mary-Milk Rivers Development	465,000	1,224,330	793,622
United Irrigation District	34,000	61,394	36,836
Aetna Irrigation District	7,300	14,683	8,810
Mountain View Irrigation District	3,600	7,241	4,345
Leavitt Irrigation District	4,400	8,850	5,310
Macleod Irrigation District	5,000	9,543	6,203
Ross Creek Irrigation District	2,300	6,417	4,492
Small Projects	70,000	87,500	61,250
	1,283,600	3,367,265	2,119,054

$$\frac{\text{Gross Diversion}}{\text{Irrigable Area}} = 2.62 \text{ ac.ft./ac.}$$

$$\frac{\text{Net Depletion}}{\text{Irrigable Area}} = 1.65 \text{ ac.ft./ac.}$$

The gross diversion for irrigation purposes is 2.57 acre feet per acre and the net depletion from the stream is estimated at 1.63 acre feet per acre for the entire group of projects.


PROVINCE · OF · ALBERTA
WATER RESOURCES OFFICE · EDMONTON
MAP SHOWING EXISTING IRRIGATION PROJECTS, AND PROPOSED DEVELOPMENT IN SOUTHERN ALBERTA.
PROJECT
IRRIGABLE AREA IN ACRES
EASTERN IRRIGATION DISTRICT 281,000
WESTERN IRRIGATION DISTRICT 75,000
BOW RIVER PROJECT 240,000
LETHBRIDGE NORTHERN IRRIGATION DISTRICT 7,600
ST MARY RIVER DEVELOPMENT 665,000
UNITED IRRIGATION DISTRICT 54,000
ALTA IRRIGATION DISTRICT 7,500
MOUNTAIN VIEW IRRIGATION DISTRICT 3,600
LEAVITT IRRIGATION DISTRICT 4,400
MACLEOD IRRIGATION DISTRICT 9,000
BOSS TRACK IRRIGATION DISTRICT 2,300
SMALL PROJECTS 10,000
2,765,600 Acres
WESTERN IRR. DISTRICT
BOW RIVER PROJECT
WEST BLOCK
EAST BLOCK
CUTBANK EXTENSION
MEDICINE HAT EXTENSION
REDCLIFF-MED. HAT EXTENSION
PROPOSED REDCLIFF-BOWLAND EXTENSION
DEVELOPMENT
MILK RIVER
ST. MARY
INTERNATIONAL BOUNDARY
MONTANA
GLACIER NATIONAL PARK
WATERTON LAKES PARK
FRESNO RESERVOIR
FIFTH MERIDIAN
SOUTH MERIDIAN
LEGEND
Boundaries of Existing Districts
Areas of Proposed Development in St Mary & Milk River Project
Other Possible Development
Scale 1 in = 6 Miles

SUBMISSION TO PRAIRIE PROVINCES WATER BOARD FOR RECONSIDERATION OF ALBERTA'S ALLOCATIONS FOR ITS IRRIGATION PROJECTS

APPENDIX "A"

EASTERN IRRIGATION DISTRICT

The Eastern Irrigation District records (table 1) show the gross diversion, irrigable area and the area actually irrigated during the period 1951 to 1962.

TABLE I

Year	Gross Diversion Ac. Ft.	Irrigable Area Acres	Area Irrigated Acres	Irrigation Factor Percentage	Gross Div. Irr. Area Ac.Ft./Ac.	Gross Div. Area Irr. Ac.Ft./Ac.
1951	243780	183316	152869	83.3	1.33	1.59
1952	342660	184500	127422	69.0	1.86	2.69
1953	205710	189496	96130	50.8	1.09	2.14
1954	366390	191871	148446	77.3	1.91	2.47
1955	388850	191568	148892	77.7	2.03	2.61
1956	375810	190976	151239	79.2	1.97	2.48
1957	510030	189928	166887	87.8	2.69	3.06
1958	478720	190845	156809	82.1	2.51	3.05
1959	416300	188721	154666	81.9	2.21	2.69
1960	493110	188341	167597	89.0	2.62	2.94
1961	652210	189421	170413	90.0	3.44	3.83
1962	566840	190170	171495	90.1	2.98	3.31
Average	420042	189096	151072	79.9	1.88	2.73

The present allocation from the Prairie Provinces Water Board is for 281,000 acres and amounts to 562,000 acre feet.

We have assumed the following to be true in the computation of requirements for the Eastern Irrigation District:

1. Irrigation factor - 95%
2. Irrigation efficiency - 55%
3. Conveyance and reservoir losses - 40%
4. Return flow - 40%

The justification for these assumptions is as follows:

1. IRRIGATION FACTOR.

The Eastern Irrigation District records show that since 1960, on the average, 90% of the total acreage classified as irrigable has been irrigated. The records also show a general trend in the district of progressively less land being left idle in any year. This in part, at least, is due to the change from the growing of grain to the production of feed and the raising of livestock.

If the present trend continues, by the year 1970 the irrigation factor should reach 95%. It must be remembered that it is in the drier years the irrigation factor is highest and it is also in those years that the maximum amount of water is required. This submission is based therefore on the condition which would occur in a dry year, and it is consequently assumed that an irrigation factor of 95% would be reached during the life of the new allocations.

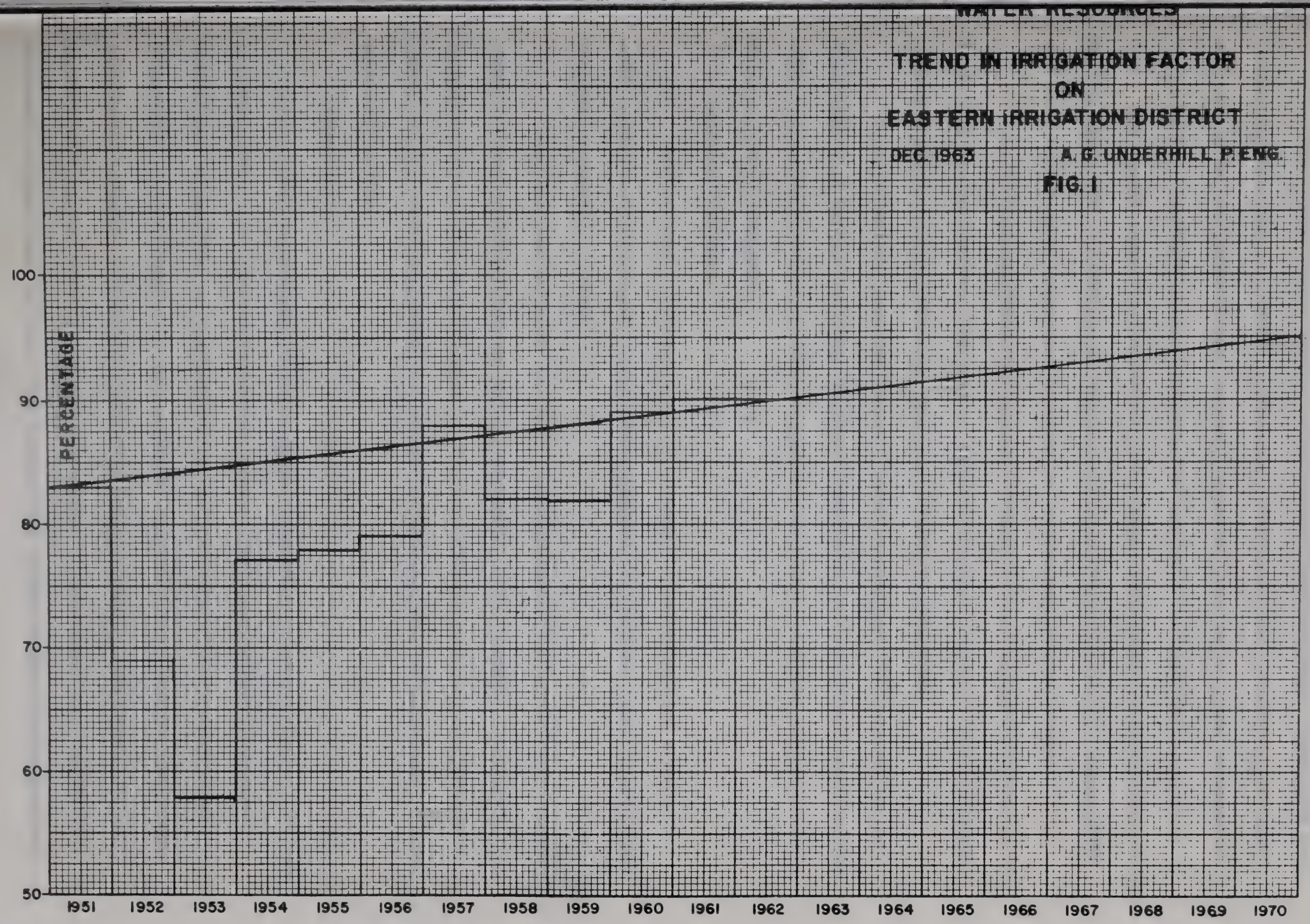
The graph (see Fig. 1) shows that, based on the trend over the last 12 years, this figure is reasonable.

WATER RESOURCES

TREND IN IRRIGATION FACTOR ON EASTERN IRRIGATION DISTRICT

DEC. 1963 A. G. UNDERHILL P. ENG.

FIG. 1



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2. IRRIGATION EFFICIENCY.

It is a well known fact that the irrigation efficiency on Alberta irrigation projects is low, probably less than 50%. This is not only true for Alberta but also for those all over the world.

The United States Senate in its report "Land and Water Potentials and Future Requirements for Water" in December 1959 noted that the 1954 irrigation efficiency in the United States varied between 45% and 60%. Areas comparable to the Alberta irrigation projects have an irrigation efficiency on the average of 45%. The Senate report estimated that such areas would have an efficiency of 55% by the year 1980, at which time the whole United States would vary between 55% and 65%. The higher figure would occur in the Eastern United States.

It is expected that the Eastern Irrigation District should increase to about 55% during the next ten years. This will occur, largely due to a concentrated program of land levelling and farm irrigation education.

It is further expected that a farm efficiency of 60% referred to in "The Underhill Report" will be reached at some time in the future, but like the 100% irrigation factor, the 60% irrigation efficiency is beyond the period of this allocation request.

3. CONVEYANCE LOSSES.

The 40% used in determining the losses in conveyance and storing of water prior to its delivery to the farm headgate is the same figure used in the original submission in 1949.

Any information that has been collected during the intervening period tends to confirm this figure as being reasonable. For example, the Water Resources Branch of the Department of Northern Affairs and National Resources found, during June 1963, that in a single 20 mile section of main canal, losses amounted to 13%.

4. RETURN FLOW.

In the calculation of the original submission a return flow of 15% was assumed. Since that time measurements made by the Federal Water Resources Branch have shown that on the Eastern Irrigation District the return flows exceed 31%. These figures do not represent all the surface return flow since many small streams, too small to measure, return water to the river. While measurements may be made of a small proportion of the subsurface return flow, obviously a great deal of this flow reaches the rivers without being measured.

During the period 1951-62 the return flow has averaged 31% on the Eastern Irrigation District. In the dry year of 1961 the measured return flow amounted to 19%. To this must be added the unmeasured return surface flows and the unmeasured subsurface flows.

Indications obtained from the Red Deer River allow us to believe that the unmeasured return flows are considerable. Stations have been established on the Red Deer, Bow and Oldman Rivers to try to assess the total return flows to these rivers from our irrigation projects.

It might be noted that the U. S. Bureau of Reclamation uses the following formula to determine return flows:

Return flow = gross diversion - 1.25 x net irrigation requirements.

In the case of the Eastern Irrigation District, application of this formula results in a return flow of 57% of gross diversions.

In this submission, the amount of return flow has been assumed to be 40% of the gross diversion. It is expected that future measurements will show this figure to be low and indicates the need to increase it at some future time.

The Blaney-Criddle method has been used in determining the irrigation requirements, as suggested in "The Underhill Report". We have used the graphs available in that report in our determinations, and hence have used the same cropping pattern.

Table (2) shows the complete calculations for the Eastern Irrigation District using the assumptions mentioned above. It shows that a gross diversion of 840,893 acre feet of water is required to irrigate the 281,000 acres, and that this will result in a net depletion from the stream of 504,536 ac. ft. This amounts to 2.99 acre feet per irrigable acre or 3.15 acre feet per acre of irrigation. The net depletion is 1.80 acre feet per irrigable acre or 1.89 acre feet per acre irrigated.

In addition to this water for irrigation purposes, water for municipal, industrial and other purposes is required. Table (3) shows the requirements for these demands within the Eastern Irrigation District. Thus, to the gross diversion of 840,893 acre feet for irrigation purposes must be added 38,660 acre feet which is supplied through the works of the Eastern Irrigation District for municipal, industrial and other purposes. This produces a total gross diversion of 879,553 acre feet and a total net depletion from the stream of 523,866 acre feet. This water must all be supplied to the irrigation district during the ice-free season since it is impossible to operate these canals during the winter period.

TABLE 2

PROJECT: Eastern Irrigation District

IRRIGABLE AREA: 281,000 Acres

IRRIGATION FACTOR: 95%

NET AREA IRRIGATED: 266,950 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 20.2 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 7.7 inches

3. Net Irrigation Requirements (a) (1)-(2) 12.5 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 278,073 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 55 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ 22.7 inches = 1.89 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 504,536 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 40 % of Gross Diversion = 336,357 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 840,893 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 40 % of Gross Diversion = 336,357 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 504,536 Ac.Ft.

$\frac{\text{Gross Requirements}}{\text{Irrigable Area}}$ = 2.99 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Irrigable Area}}$ = 1.80 Ft/Ac.

$\frac{\text{Gross Requirements}}{\text{Area Irrigated}}$ = 3.15 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Area Irrigated}}$ = 1.89 Ft/Ac.

TABLE 3

PROJECT: Eastern Irrigation District

Municipal & Industrial	Gross	
Brooks	1,660	Ac. Ft.
Bassano	1,323	
Duchess	30	
Rosemary	29	
Tilley	34	
Other users	120	
Recreation and Wildlife	20,000	
Total	23,196	Ac. Ft.
Conveyance Losses (40%)		
Gross Diversion Requirements	38,660	Ac. Ft.
Return Flow (50%)	19,330	Ac. Ft.
Net Depletion	19,330	Ac. Ft.

WESTERN IRRIGATION DISTRICT

The Western Irrigation District, because of its irrigation and stockwater deliveries, presents a difficult problem in assessing its water requirements. For this reason the irrigation requirements have been separated into two parts:

(a) water requirements for irrigation

(b) water requirements for stockwatering purposes

Water Requirements for Irrigation.

The district has 75,000 acres of irrigable land. In the year 1949 the district's acreage was, if anything, on the decline, however, with the drier years toward the end of the 1950's the district has started a steady trend of expansion. It is anticipated that the district will reach 75,000 acres during the period of the proposed allocation. Fig. (2).

IRRIGATION FACTOR.

Due to the fact that this district is actually in a marginal area and that, at least for the period under consideration, the greater part of the irrigated area will only be irrigated as supplemental irrigation; the irrigation factor will not rise as fast as in other districts where irrigation is a prime necessity. For this reason the irrigation factor has not been increased over that used in Alberta's 1949 submission.

IRRIGATION EFFICIENCY.

The farm efficiency in a marginal irrigation district is generally very low. Crops can be grown in most years with little or no irrigation. While the yield is not as good as it would be under irrigation, it is good enough to make farming a success. Under these conditions little incentive exists for any but the best farmers to improve their lands by levelling or to practise better irrigation procedures. For this reason it is doubtful if an efficiency of greater than 50% will result in the period under consideration.

CONVEYANCE LOSSES.

The 30% conveyance losses used in the 1949 submission has been again used in this submission. There are no indications that this figure is in error from any data collected in the intervening period.

RETURN FLOW.

The return flow from this district has been estimated at 45%. It must be noted that this is 45% of the water diverted for irrigation purposes; not 45% of the total diversion. Measured surface return flow since 1957 has averaged 44%

WATER RESOURCES

TREND IN IRRIGATION DEVELOPMENT
ON
WESTERN IRRIGATION DISTRICT

DEC. 1963 A. G. UNDERHILL P.ENG.

FIG. 2

AREA IRRIGATED IN ACRES

70000
60000
50000
40000
30000
20000
10000
0

1951 1952 1953 1954 1955 1956 1957 1958 1959 1960 1961 1962 1963 1964 1965 1966 1967 1968 1969 1970

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with a minimum of 29% in 1962. To this must be added all the unmeasured surface flow as well as the subsurface flow. We feel that an estimate of 45% return flow is low but until sufficient information is available to justify a higher figure, this is the figure that is being used. If return flow from stockwater is added to this, the total estimated return flow is 48% of gross diversion.

We must note again the United States Bureau method of computing return flows gives a figure of 57%.

STOCKWATER

Discussions with the Western Irrigation District have shown that it takes approximately 10 acre feet at the point of delivery to supply one stockwater user. The stockwater user is a farmer along the canal who has no irrigation rights on the particular farm unit. We have accepted this 10 acre feet at the point of delivery as being reasonable. To this must be added conveyance losses in order to assess the gross requirement. Using a 30% conveyance loss results in a gross requirement of 14.3 acre feet per delivery.

The return flow from this type of delivery is extremely high. Water is kept flowing in a natural channel or a canal during most of the irrigation season. Only a small proportion of the water is used. It is estimated that at least 75% of the gross diversion is returned to the stream. This means that the net depletion is 25%, or 3.6 acre feet per delivery.

At the present time the Western Irrigation District has 500 stockwater deliveries. It is not expected that this figure will increase since the expansion of the irrigable area will, to a large extent, compensate for any expansion in stockwater deliveries. In other words, when a present stockwater user decides to become an irrigator he automatically becomes entitled to water for domestic purposes which includes stockwater. He would therefore be removed from the number of stockwater users, thus providing for additional stockwater deliveries without materially increasing the total number of stockwater users.

We have assumed therefore that the number of stockwater deliveries on the Western Irrigation District will remain constant at 500. Thus, some 7,150 acre feet at the point of diversion is required to supply this use. Of the 7,150 acre feet diverted there would be a net depletion of 1,800 acre feet.

The gross requirements for irrigation and stockwater for the Western Irrigation District would consequently be 150,292 acre feet with a net depletion of 80,528 acre feet.

The Western Irrigation District requirements show a gross diversion for irrigation purposes of 1.91 acre feet per acre based on the irrigable area, and 2.4 acre feet per acre based on the area actually irrigated.

In addition to the water required for irrigation and stockwater the Western Irrigation District supplies water for Gleichen, Strathmore and Rockyford as well as a number of recreation and wildlife projects which are also generally used for stockwatering.

Table (5) shows the requirements for the supply for this purpose. This is water carried in the canals of the Western Irrigation District and must be added to the irrigation and stockwater requirements to meet the demands in the district.

A gross diversion of 9,133 acre feet is required to satisfy these demands with a net depletion of 4,566 acre feet. This means the total requirements of the Western Irrigation District are 159,425 acre feet at the point of diversion with a total net depletion of 85,094 acre feet.

TABLE 4

PROJECT: Western Irrigation District

IRRIGABLE AREA: 75,000 Acres

IRRIGATION FACTOR: 80%

NET AREA IRRIGATED: 60,000 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 19 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 9 inches

3. Net Irrigation Requirements (a) (1)-(2) 10 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 50,000 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 50 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 20 inches = 1.67 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 100,200 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 42,942 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 143,142 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 45 % of Gross Diversion = 64,414 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 78,728 Ac.Ft.

12. 500 Stockwater Deliveries at 10 Ac.Ft./Del. = 5,000 Ac.Ft.

    Conveyance Loss 30%

    Gross Diversion Requirement (14.3 Ac.Ft./Del.) = 7,150 Ac.Ft.

    Return Flow 75% = 5,350 Ac.Ft.

    Net Depletion = 1,800 Ac.Ft.

TABLE 5

PROJECT: Western Irrigation District

Municipal & Industrial		Gross
Gleichen		480 Ac. Ft.
Strathmore		580 Ac. Ft.
Rockyford		33 Ac. Ft.
Other Users		300 Ac. Ft.
Recreation & Wildlife		5,000 Ac. Ft.
	Total	6,393 Ac. Ft.
Conveyance Losses (30%)		
Gross Diversion Requirements		9,133 Ac. Ft.
Return Flow (50%)		4,567 Ac. Ft.
Net Depletion		4,566 Ac. Ft.

SUMMARY OF REQUIREMENTS

(Quantities in Ac.Ft.)

	Irrigation	Stockwater	Other Uses	Total
Gross Diversion	143,142	7,150	9,133	159,425
Return Flow	64,414	5,350	4,567	74,331
Net Depletion	78,728	1,800	4,566	85,094

BOW RIVER PROJECT

The Bow River Project is located in the same general area as the Eastern Irrigation District. It has the same consumptive use, effective rainfall and net irrigation requirements as the Eastern Irrigation District. Its farmers practise the same type of irrigation, generally, as the Eastern Irrigation District farmers. Therefore, based on the same justifications as were used in the Eastern Irrigation District, the same assumptions have been used for irrigation factor, irrigation efficiency and conveyance losses in the Bow River Project.

The return flow of 35% is based on the results of the Federal Water Resources report on return flows of 20%, plus 15% to take care of the unmeasured return surface flows plus the subsurface return flows.

The United States Bureau of Reclamation method of calculating return flows gives a figure of 57% for the Bow River Project.

As a result of these assumptions the gross requirement for the Bow River Project (see Table 6) for irrigation purposes is 718,200 acre feet with a net depletion from the stream of 466,830 acre feet. This means the Bow River Project requires 2.99 acre feet per acre of irrigable land or 3.15 acre feet per acre of land irrigated. The net depletion from the stream amounts to 1.95 acre feet per acre of irrigable land or 2.05 acre feet per acre of land irrigated.

Table (7) shows the additional water required to be carried in the works of the Bow River Project to satisfy the demands of municipal and industrial users. This means that the Bow River project's total gross diversion requirement to satisfy all demands is 720,680 acre feet and that the project and its other users deplete the stream by 468,070 acre feet during the year.

TABLE 6

PROJECT: Bow River Development

IRRIGABLE AREA: 240,000 Acres

IRRIGATION FACTOR: 95%

NET AREA IRRIGATED: 228,000 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 20.2 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 7.7 inches

3. Net Irrigation Requirements (a) (1)-(2) 12.5 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 237,500 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 55 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 22.7 inches = 1.89 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 430,920 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 40 % of Gross Diversion = 287,280 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 718,200 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 35 % of Gross Diversion = 251,370 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 466,830 Ac.Ft.

$\frac{\text{Gross Requirements}}{\text{Irrigable Area}}$ = 2.99 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Irrigable Area}}$ = 1.95 Ft/Ac.

$\frac{\text{Gross Requirements}}{\text{Area Irrigated}}$ = 3.15 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Area Irrigated}}$ = 2.05 Ft/Ac.

TABLE 7

PROJECT: Bow River Development

	Gross
Municipal & Industrial	
Arrowwood	30 Ac. Ft.
Enchant	40 Ac. Ft.
Hays	37 Ac. Ft.
Lomond	34 Ac. Ft.
Milo	22 Ac. Ft.
Vauxhall	325 Ac. Ft.
Recreation & Wildlife	1,000 Ac. Ft.
Total	1,488 Ac. Ft.
Conveyance Losses (40%)	
Gross Diversion Requirements	2,480 Ac. Ft.
Return Flow (50%)	1,240 Ac. Ft.
Net Depletion	1,240 Ac. Ft.

LETHBRIDGE NORTHERN IRRIGATION DISTRICT

The Lethbridge Northern Irrigation District is located in an area with a slightly higher effective precipitation and a slightly lower consumptive use requirement than for the projects herein previously considered. This tends to have the effect of reducing the irrigation factor. There is more chance that a successful crop can be grown without irrigation, and this increases the chance that all the area will not be irrigated in any one year. In the period 1960 to 1962 the average irrigation efficiency was 80%. Assuming that in this district, as in the others, the general trend to more efficient farm practises will continue and the irrigation factor will increase, an 85% irrigation factor for the period under consideration has been assumed.

The district is well developed and has a successful specialized crop production. The farms in general are well and efficiently irrigated. On the basis of the same assumption used in determining the irrigation factor, namely, that the trend to more efficient operation and irrigation methods will continue during the period under consideration, an irrigation efficiency of 55% has been adopted.

The conveyance losses are rated at 30% of the gross diversion. This is 7% greater than that used in Alberta's original submission. We have long felt that the original 23% conveyance loss was too low. The canals, for part of their length, pass through a gravelly soil, and in other areas through sections which are underlain with sandstone. These conditions have resulted in greater seepage losses than originally contemplated. We believe that 30% more truly represents the canal and reservoir losses in this district.

The return flows have been estimated at 35%. This is in keeping with the return flows estimated for other districts where partial measurements are available. It is made up of 25% estimated surface return flows and 10% subsurface return flows. As mentioned for other districts, the Bureau of Reclamation method gives an estimated 52% return flow for this district.

Using these assumptions we find (Table 8) that the Lethbridge Northern Irrigation District requires 185,349 acre feet per year as a gross diversion for irrigation purposes. The irrigation portion of the district causes a net depletion in the stream of 120,477 acre feet. This is 1.93 acre feet per acre of irrigable land or 2.27 acre feet per acre of acre irrigated as a gross diversion. The net depletion is 1.25 acre feet per irrigable acre and 1.48 acre feet per acre irrigated.

In addition, Table (9) shows the water which must be carried through the district's works to satisfy other demands. The district requires an additional diversion of 2,300 acre feet per year to meet these requirements. This results in a net depletion from the stream of 1,150 acre feet.

The total diversion requirement therefore is 187,649 acre feet of which 121,627 acre feet is never returned to the stream.

TABLE 8

PROJECT: Lethbridge Northern Irrigation District

IRRIGABLE AREA: 96,000 Acres

IRRIGATION FACTOR: 85%

NET AREA IRRIGATED: 81,600 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 19.3 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 8.8 inches

3. Net Irrigation Requirements (a) (1)-(2) 10.5 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 71,400 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 55 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 19.1 inches = 1.59 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 129,744 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 55,605 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 185,349 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 35 % of Gross Diversion = 64,872 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 120,477 Ac.Ft.

$\frac{\text{Gross Requirement}}{\text{Irrigation Area}}$ = 1.93 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Irrigation Area}}$ = 1.25 Ft/Ac.

$\frac{\text{Gross Requirement}}{\text{Area Irrigated}}$ = 2.27 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Area Irrigated}}$ = 1.48 Ft/Ac.

TABLE 8

PROJECT: Lethbridge Northern Irrigation District

Municipal & Industrial	Gross
Barons	70 Ac. Ft.
Picture Butte	325 Ac. Ft.
Nobleford	50 Ac. Ft.
Shaughnessy	15 Ac. Ft.
Turin	50 Ac. Ft.
Other Users	100 Ac. Ft.
Recreation & Wildlife	1,000 Ac. Ft.
Total	1,610 Ac. Ft.
Conveyance Losses (30%)	
Gross Diversion Requirements	2,300 Ac. Ft.
Return Flow (50%)	1,150 Ac. Ft.
Net Depletion	1,150 Ac. Ft.

ST. MARY-MILK RIVERS DEVELOPMENT

The irrigable area used in Alberta's 1949 submission for the St. Mary-Milk Rivers Development was 465,000 acres. Mr. Foss, in his submission, noted that the potential area now is closer to 490,000 acres. In fact, the acreage which may be irrigated is entirely dependent on the water supplies and storage reservoirs available to control the water. We feel the 465,000 acres is reasonable in view of the water available in a dry year.

The net irrigation requirements for the project are not 11.75 inches throughout the whole project. This is the average figure which will allow for a variable irrigation requirement throughout the project. Both the consumptive use of the plants and the effective rainfall vary from east to west. Lethbridge has a consumptive use requirement of 19.25 inches and an effective rainfall of 8.94 inches. Medicine Hat, on the other hand, has a high consumptive use requirement of 21.59 inches and a lower effective rainfall (7.54) resulting in a greater irrigation water requirement. The net irrigation requirement in the Lethbridge area is 10.31 inches and in the Medicine Hat area 14.05 inches.

IRRIGATION FACTOR

The management of the district indicated during discussions at the meeting in Lethbridge that the irrigation factor already exceeds 90%. Indications are that it should reach 95% during the period of this proposed allocation.

IRRIGATION EFFICIENCY

Like all other districts, considerable improvement in the irrigation efficiency has occurred over the last few years. Land levelling and improved irrigation practises has resulted in most of this improvement. The farmer in these dry years has become more aware of the value of water and the need for proper irrigation practises. It is thought that the 60% irrigation efficiency used in the Underhill Report will be reached sometime in the future, but the best that can be hoped for during the period under consideration is 55%.

CONVEYANCE LOSSES

The conveyance losses of 30% used in Alberta's 1949 submission was too low in view of the length of the main canal system. Water diverted from the Waterton River could be carried by canal into the Medicine Hat area approximately 200 miles away. We have raised the conveyance losses to 35% to take care of this factor.

Mr. Foss has estimated the main canal loss at 10%, distribution canal loss at 20% and about 5% as a reservoir loss. The district also agrees that these figues are reasonable when considered in the light of experience.

RETURN FLOW

Using the Federal Water Resources records on the Eastern, Western and Bow River projects as a guide, we have estimated the return flow from the St. Mary-Milk Rivers project as 35% of the gross diversion.

Again, the U.S. Bureau of Reclamation method gives a considerably higher return flow estimate of 54%. Future measurements will allow us to apply for further correction to this estimate since allocations are approved on a continuing basis.

Using these assumptions and "The Underhill Report" maps for the Blaney-Criddle method it is found that the St. Mary-Milk Rivers project requires a gross diversion of 1,209,715 acre feet for irrigation purposes and will cause a net depletion from the stream of 786,315 acre feet. This amounts to a gross diversion of 2.60 acre feet per irrigable acre and 2.75 acre feet per acre irrigated. The net depletion is 1.69 acre feet per irrigable acre and 1.78 acre feet per acre irrigated.

The municipal, industrial and other uses delivered through the works of the St. Mary-Milk Rivers Development are listed on Table (11). The quantities shown are for the year 1970 and are based on a report, "Future Water Requirements for Municipal and Industrial Use in Alberta" by Mr. A.G. Underhill. For existing developments it is shown that 14,615 acre feet per year would be required to be diverted by the St. Mary-Milk Rivers project to supply municipal, industrial, wildlife and recreation uses as well as other non-irrigation requirements in the area. Of this 14,615 acre feet, it is estimated that some 7,307 acre feet are not returned to the stream.

This makes the total diversion requirement for the St. Mary-Milk Rivers project some 1,224,330 acre feet of which some 793,622 acre feet is consumptively used.

TABLE 10

PROJECT: St. Mary-Milk Rivers Project

IRRIGABLE AREA: 465,000 Acres

IRRIGATION FACTOR: 95%

NET AREA IRRIGATED: 441,750 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 20.0 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 8.25 inches

3. Net Irrigation Requirements (a) (1)-(2) 11.75 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 432,547 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 55 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 21.4 inches = 1.78 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 786,315 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 35 % of Gross Diversion = 423,400 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) =1,209,715 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 35 % of Gross Diversion = 423,400 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 786,315 Ac.Ft.

$\frac{\text{Gross Diversion}}{\text{Irrigable Area}}$ = 2.60 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Irrigable Area}}$ = 1.69 Ft/Ac.

$\frac{\text{Gross Diversion}}{\text{Acreage Irr.}}$ = 2.74 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Acreage Irr.}}$ = 1.78 Ft/Ac.

TABLE 11

PROJECT: St. Mary-Milk Rivers Project

	Gross
Municipal & Industrial	
Bow Island	818 Ac. Ft.
Burdett	38 Ac. Ft.
Coaldale	1,624 Ac. Ft.
Grassy Lake	33 Ac. Ft.
Taber	2,666 Ac. Ft.
Raymond	1,321 Ac. Ft.
Recreation & Wildlife	3,000 Ac. Ft.
Total	9,500 Ac. Ft.
Conveyance Losses (35%)	
Gross Diversion Requirements	14,615 Ac. Ft.
Return Flow (50%)	7,308 Ac. Ft.
Net Depletion	7,307 Ac. Ft.

UNITED IRRIGATION DISTRICT

The assumptions made for this district are as follows:

IRRIGATION FACTOR

No change has been made to the Irrigation Factor since the 1949 submission. The district is in an area where irrigation is considered to be marginal. In other words, it may be possible to grow crops successfully without the use of irrigation water in many years. This tends to keep the irrigation down since a farmer must decide if and when to irrigate and the "if" can be a deciding factor.

IRRIGATION EFFICIENCY

In view of the type of land and the type of crops grown in this district it would appear that the district has relatively little chance of reaching the irrigation efficiency of those districts where irrigation every year is an essential factor. The desire to improve the land by levelling and to improve the irrigation practises does not have the same urgency here as in other irrigation area. However, the dry years have caused an awareness that may result in a 50% irrigation efficiency being reached during the life of this allocation. In time the efficiency of irrigation will rise to a higher percentage but only when greater demands on production are made from these lands.

CONVEYANCE LOSSES

In the original submission the conveyance losses were set at 20% of the gross diversion. Under present conditions, and in the light of present knowledge, these figures appear to be extremely low and unreasonable. We have therefore increased the conveyance losses to 30% which is more compatible with present day estimates of losses.

RETURN FLOW

In all cases the return flow percentage has been increased to better compare with the measured return flows from other districts. The 40% used for this district appears too low, but is probably the best estimate at the present time.

If an analysis is made of the flow records on the Belly River at Mountain View and Standoff before and since irrigation, it is found that the average inflow since irrigation is almost double that recorded prior to irrigation.

In the period 1913 to 1924 the average inflow between Mountain View and Standoff was 25,660 acre feet. In the period 1948 to 1961 the average inflow was 54,660 acre feet or 28,830 acre feet more than in the period 1913 to 1924. When it is considered that at least part of this flow of 28,830 acre feet must be the return flow from the United Irrigation District, it must be realized that the return flow from this district is very appreciable and could be much higher

than the 40% estimate.

The United States Bureau of Reclamation method of computing return flow indicates that 56% of the diversion should be return flow.

Our computations find the United Irrigation District requires a gross diversion of 61,394 acre feet and results in a net depletion from the stream of 38,836 acre feet. This is 1.81 acre feet per irrigable acre and 2.26 acre feet per acre irrigated. The net depletion is 1.08 acre feet per irrigable area and 1.35 acre per acre irrigated.

The United Irrigation District does not supply any quantity of water for purposes other than irrigation use at the present time and it is not anticipated that this will occur in the foreseeable future.

TABLE 12

PROJECT: United Irrigation District

IRRIGABLE AREA: 34,000 Acres

IRRIGATION FACTOR: 80%

NET AREA IRRIGATED: 27,200 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 19.0 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 9.5 inches

3. Net Irrigation Requirements (a) (1)-(2) 9.5 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 21,533 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 50 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 19.0 inches = 1.58 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 42,976 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 18,418 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 61,394 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 40 % of Gross Diversion = 24,558 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 36,836 Ac.Ft.

$\frac{\text{Gross}}{\text{Irr. Area}}$ = 1.81 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Irr. Area}}$ = 1.08 Ft/Ac.

$\frac{\text{Gross}}{\text{Acreage Irr.}}$ = 2.26 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Acreage Irr.}}$ = 1.35 Ft/Ac.

AETNA, MOUNTAIN VIEW AND LEAVITT IRRIGATION DISTRICTS

The Aetna, Mountain View and Leavitt Irrigation Districts have been included together in this report since they operate in the same area and under similar conditions. Tables (13), (14) and (15) show their requirements.

IRRIGATION FACTOR

These districts, like the United Irrigation District, are in an area where irrigation is considered marginal. Therefore, the 80% irrigation factor used in Alberta's 1949 submission appears to be still reasonable.

IRRIGATION EFFICIENCY

These districts are in a rolling type of land where irrigation is marginal and their efficiency is extremely low. It is estimated by the year 1970 that the districts will probably reach irrigation efficiency of 45%. It will be an extremely long period before they are able to reach the 60% used in the Underhill Report and when this occurs it will be due to increased demands on the lands by the farmers.

CONVEYANCE LOSSES

Due to the marginal nature of the irrigation in this area and to the type of land being traversed the conveyance losses are relatively high. For this reason 30% has been used as the conveyance losses in these districts.

RETURN FLOW

Return flows are relatively high in these districts due to the method of operation and the type of irrigation practised. It is estimated that 40% is a reasonable estimate with our present knowledge of these districts.

The gross requirements and net depletions for these districts are as follows:

Irrigation District	Gross Requirements	Net Depletion
Aetna	14,683	8,810
Mountain View	7,241	4,345
Leavitt	8,850	5,310
	30,774 Ac. Ft.	18,465 Ac. Ft.

This means that 2.01 acre feet per acre of irrigable land is required, or 2.51 acre feet per acre irrigated. The net depletion to the stream is 1.21 acre feet per acre of irrigable land or 1.51 acre feet per acre irrigated.

These districts do not supply water for use other than irrigation at the present time and it is not anticipated that they will during the foreseeable future.

TABLE 13

PROJECT: Aetna Irrigation Project

IRRIGABLE AREA: 7,300 Acres

IRRIGATION FACTOR: 80%

NET AREA IRRIGATED: 5,840 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 19.0 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 9.5 inches

3. Net Irrigation Requirements (a) (1)-(2) 9.5 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 4,623 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 45 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 21.1 inches = 1.76 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 10,278 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 4,405 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 14,683 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 40 % of Gross Diversion = 5,873 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 8,810 Ac.Ft.

TABLE 14

PROJECT: Mountain View Irrigation District

IRRIGABLE AREA: 3,600 Acres

IRRIGATION FACTOR: 80%

NET AREA IRRIGATED: 2,880 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 19.0 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 9.5 inches

3. Net Irrigation Requirements (a) (1)-(2) 9.5 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 2,280 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 45 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 21.1 inches = 1.76 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 5,069 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 2,172 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 7,241 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 40 % of Gross Diversion = 2,896 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 4,345 Ac.Ft.

TABLE 15

PROJECT: Leavitt Irrigation District

IRRIGABLE AREA: 4,400 Acres

IRRIGATION FACTOR: 80%

NET AREA IRRIGATED: 3,520 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 19.0 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 9.5 inches

3. Net Irrigation Requirements (a) (1)-(2) 9.5 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 2,787 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 45 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 21.1 inches = 1.76 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 6,195 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 2,655 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 8,850 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 40 % of Gross Diversion = 3,540 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 5,310 Ac.Ft.

Total Requirements: Aetna, Mountain View and Leavitt Districts.

$\frac{\text{Gross Requirements}}{\text{Irrigable Area}}$ = 2.51 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Irrigable Area}}$ = 1.21 Ft/Ac.

$\frac{\text{Gross Requirements}}{\text{Area Irrigated}}$ = 2.01 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Area Irrigated}}$ = 1.51 Ft/Ac.

MACLEOD IRRIGATION DISTRICT

This district is relatively close to the Lethbridge Northern Irrigation District and except for the lower irrigation factor the figures are the same.

We do not feel that this district, which is a younger district, will reach the same stage of development as the Lethbridge Northern for some years and hence we have used an irrigation factor of 80%.

The gross requirements for this district is 9,543 acre feet per year with a net depletion from the stream of 6,203 acre feet. This represents a use of 1.91 acre feet per irrigable acre, or 2.39 acre feet per acre irrigated. The net depletion from the stream is 1.24 acre feet per irrigable acre, or 1.55 acre feet per acre irrigated.

TABLE 16

PROJECT: Macleod Irrigation District

IRRIGABLE AREA: 5,000 Acres

IRRIGATION FACTOR: 80%

NET AREA IRRIGATED: 4,000 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 19.0 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 9.0 inches

3. Net Irrigation Requirements (a) (1)-(2) 10.0 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 3,333 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 50 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 20.0 inches = 1.67 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 6,680 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 2,863 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 9,543 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 35 % of Gross Diversion = 3,340 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 6,203 Ac.Ft.

$\frac{\text{Gross}}{\text{Irr. Area}}$ = 1.91 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Irr. Area}}$ = 1.24 Ft/Ac.

$\frac{\text{Gross}}{\text{Acres Irr.}}$ = 2.39 Ft/Ac. $\frac{\text{Net Depletion}}{\text{Acres Irr.}}$ = 1.55 Ft/Ac.

ROSS CREEK IRRIGATION DISTRICT

This district containing some 2,300 acres of irrigable land was built since the 1949 submission. It receives its water supply from Gross Ventre Creek and Ross Creek which are tributaries of the South Saskatchewan River near Medicine Hat.

Generally, in years when water is available, the land in the district has an extremely high irrigation factor for the type of irrigation practised. A 90% irrigation factor has therefore been used.

Conveyance losses are about average for irrigation districts in Alberta. The district has one main canal with relatively high losses but practically no laterals which compensate to a degree for the losses in the main canal. Thirty percent (30%) has been used for the conveyance losses. This includes the losses on Cavan Reservoir.

Return flow is low due to the long distance from the main stream. Evaporation and seepage losses of the waste water is high. For this reason 30% has been used.

The Ross Creek Irrigation District has a gross diversion requirement of 6,417 acre feet and a net depletion from the stream of 4,492 acre feet. The gross requirements per irrigable acre are 2.79 acre feet and the gross requirements per acre irrigated are 3.10 acre feet. The net depletion is 1.95 acre feet irrigable acre or 2.17 acre feet per acre irrigated.

It should be noted that the water supply for this district is from a non-perennial stream and hence the district is subject to problems and shortages in water supply, and in many years must make do with much less than the optimum supply.

TABLE 17

PROJECT: Ross Creek Irrigation District

IRRIGABLE AREA: 2,300 Acres

IRRIGATION FACTOR: 90%

NET AREA IRRIGATED: 2,070 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula 21.0 inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) 8.0 inches

3. Net Irrigation Requirements (a) (1)-(2) 13.0 inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. 2,243 Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 50 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 26.0 inches = 2.17 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 4,492 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 30 % of Gross Diversion = 1,925 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 6,417 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated: 30 % of Gross Diversion = 1,925 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 4,492 Ac.Ft.

$\frac{\text{Gross}}{\text{Irr. Area}}$ = 2.79 Ft/Ac.

$\frac{\text{Net Depletion}}{\text{Irr. Area}}$ = 1.95 Ft/Ac.

$\frac{\text{Gross}}{\text{Acreage Irr.}}$ = 3.10 Ft/Ac.

$\frac{\text{Net Depletion}}{\text{Acreage Irr.}}$ = 2.17 Ft/Ac.

SMALL PROJECTS

This list represents the smaller private irrigation projects in the Saskatchewan River Drainage Basin.

Since these projects generally depend on spring runoff the farm delivery has been arbitrarily set at 1.0 acre feet per acre. This is less than is required for maximum crop growth but it is all that they can anticipate receiving.

Conveyance losses are estimated at 20%. The canals are short and the losses should not exceed this amount generally.

Return flows are estimated at 30%. The water is held on the land longer and the infiltration is greater resulting in a smaller return flow than estimated for other types of irrigation projects.

The gross requirements are 87,500 acre feet and the net depletion from the streams is 61,250 acre feet.

This represents 1.25 acre feet per acre as a gross demand with a net depletion of 0.88 acre feet per acre.

TABLE 18

PROJECT: Small Projects

IRRIGABLE AREA: 70,000 Acres

IRRIGATION FACTOR: %

NET AREA IRRIGATED: 70,000 Acres

CALCULATION OF WATER REQUIREMENTS

1. Plant Consumptive Use (a) by measurement ..... inches
   (b) by formula ..... inches

2. (a) Rainfall During Growing Season ..... inches
   (b) Effective Rainfall (approved graph) ..... inches

3. Net Irrigation Requirements (a) (1)-(2) ..... inches
   (b) $\frac{(1)-(2)}{12}$ x Net Area Irr. ..... Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
   (b) estimated: 40 %

5. Delivery to Farm = $\frac{(3a)}{(4)}$ = 12.0 inches = 1.0 Feet

6. TOTAL FARM DELIVERY = (Net Area Irr.) x (5) = 70,000 Ac.Ft.

7. Conveyance Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated: 20 % of Gross Diversion = 17,500 Ac.Ft.

8. Reservoir Losses (a) measured: .... % of Gross Diversion = ... Ac.Ft.
   (b) estimated:.... % of Gross Diversion = ... Ac.Ft.

9. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 87,500 Ac.Ft.

10. Return Flow (a) measured: .... % of Gross Diversion = ... Ac.Ft.
    (b) estimated:.... % of Gross Diversion = 26,250 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 61,250 Ac.Ft.

$\frac{\text{Gross}}{\text{Irr. Area}}$ = 1.25 Ft/Ac.

$\frac{\text{Net Depletion}}{\text{Irr. Area}}$ = 0.88 Ft/Ac.

CALCULATION OF WATER REQUIREMENTS

NET AREA IRRIGATED: 10,000 Acres

IRRIGATION FACTOR: X

IRRIGABLE AREA: 10,000 Acres

PROJECT: Small Projects

TABLE 18

1. Farm conveyance use (a) by measurement ..... inches
(b) by formula ..... inches

2. Delivery to Farm = $\frac{(3a)}{(3b)}$ ..... = 15.0 inches = 1.0 feet

3. Net Irrigation
Requirements (a) (1)-(2) ..... inches
(b) $\frac{(1)-(2)}{15}$ x Net Area Irr. ..... Ac.Ft.

4. Irrigation Efficiency (a) measured: ..... %
(b) estimated: 40 %

5. (a) Rainfall During
Growing Season ..... inches
(b) Effective Rainfall
(approved Graph) ..... inches

6. GROSS IRRIGATION REQUIREMENTS = (6) + (7) + (8) = 81,200 Ac.Ft.

7. Reservoir Losses (a) measured: ..... % of Gross Diversion = ... Ac.Ft.
(b) estimated: ..... % of Gross Diversion = ... Ac.Ft.

8. Conveyance Losses (a) measured: ..... % of Gross Diversion = ... Ac.Ft.
(b) estimated: 20 % of Gross Diversion = 17,200 Ac.Ft.

9. TOTAL FARM DELIVERY = (Net Area Irr.) x (2) = 10,000 Ac.Ft.

10. Return Flow (a) measured: ..... % of Gross Diversion = ... Ac.Ft.
(b) estimated: ..... % of Gross Diversion = 28,320 Ac.Ft.

11. NET DEPLETION = (9) - (10) = 61,320 Ac.Ft.

$\frac{\text{Gross}}{\text{Irr. Area}}$ = 1.52 Ft\Ac. $\frac{\text{Net Depletion}}{\text{Irr. Area}}$ = 0.88 Ft\Ac.

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Underhill, A. G.

Submission to Prairie Provinces Water Board for reconsideration of Alberta's allocations for its irrigation projects.

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